approximation to the truth, the average distances of the fainter stars must be greater than those of the brighter stars; but it by no means follows that any one faint star is further from us than any one much brighter star. In fact, the supposition made has been that stars of all magnitudes may exist at all stellar distances.

On Observations of Contacts of the Limb of Venus, or Mercury, with that of the Sun. By Prof. Simon Newcomb.

During the past four years, I have had occasion to give some attention to the problem of obtaining accurate observations of the various phases of contact between the limb of an interior planet and that of the Sun. My views, as now presented, have been derived from the study of an artificial representation of a transit of *Venus*, aided by general considerations on the subject, and by the opinions and investigations of others. I am induced to present them at the present time by the researches of M. André, and the papers of Mr. Stone and Father Perry in the *Monthly Notices* for December last.

(1) If I might be allowed to criticise certain of the views of others in a general way, I should say that one defect of much of the reasoning on this subject is this: it has too generally been assumed that the geometric outlines of *Venus* and the Sun, considered as mathematical lines, can be noted in observation with the same sort of definiteness and precision as that with which the mind conceives them; and sufficient attention has not been paid to the practical difficulties which the eye meets with in representing this geometric conception. I conceive that the question whether a certain phase can or cannot be definitely distinguished and observed by the eye is to be settled by actual trial, and by a consideration of the imperfections of vision, rather than by a consideration of its purely geometric definiteness of form.

(2) One result of the trials with the artificial transit is, that there is a certain phase near that of external contact which can be observed with the same order of precision as the internal contact, provided that the proper conditions are fulfilled. Among these conditions are, that the observer shall previously have practised on the artificial transit; that he shall know at exactly what point of the Sun's limb to look for the first contact; that he shall know when to look for the contact with an uncertainty of not much less than half a minute, nor much more than a minute; and that he shall have a telescope of fixed size and power. Of course the phase thus observed will not be geometric contact, but that occurring at the time when the notch in the Sun's limb first becomes visible. This phase varies much less with variations in the atmospheric condition and in the size and power of the telescopes than might have been supposed.

(3) The phase of external contact at egress is more uncertain than at ingress, owing to the doubt of the observer as to whether the notch has or has not disappeared from his view; that doubt extending over a longer period than the doubt as to when he first sees the notch at ingress.

(4) Referring now to the spectroscopic observation of the external contact, and to Father Perry's suggestion for rendering the projection of the planet on the chromosphere visible by means of a coloured glass in order to observe this contact, which two methods are the same with respect to the optic phenomena designed to be produced, I do not think it possible to obtain a precise observation in either of these ways. The phenomenon to be observed would then be the contact of a dark limb (that of the planet) with an adjacent bright limb (that of the Sun), on a background intermediate in tint (that of the chromosphere). The result must then depend very largely on the amount of irradiation, and on the observer's acuteness of vision in seeing the slowly diminishing line of chromosphere between the planet and the Sun. The planet will, in reality, be invisible: all the observer can see will be the outline of the chromosphere, as cut out by the planet; and when the latter gets so near the limb of the Sun that the chromosphere itself is invisible—owing to the overpowering brightness of the Sun's limb—the outline of the planet can no longer be traced, and will not reappear until it is seen projected on the background of the Sun itself. I conceive, therefore, that any attempt to make different observers certainly note the same phase of such a phenomenon will result in failure. It would, however, be of interest to try the method artificially.

(5) In describing the phenomena near the time of internal contact, I shall consider the planet to be approaching egress. For reasons which I shall soon mention, the artificial transit was placed at a distance of about eleven hundred yards from the place of observation, so that a greater or less amount of atmospheric undulation was always present. Supposing, then, that the planet was approaching the Sun's limb, and the thread of light growing thin, owing to the approach of contact, the first thing which an observer would remark was that, in consequence of the constant changes of outline caused by atmospheric disturbance of the images, no set of phenomena could be described as invariable. It would be necessary to combine judgment with sight, by considering what might be called a *mean* phenomenon. Different observers might form different judgments as to what this mean phenomenon was. It would, however, always be seen that as the thread of light became quite thin, it looked darker than the rest of the Sun; and unless the atmosphere was more steady than is usual in the day-time, the line of light would occasionally be broken up into two or more very irregular threads or twists of light, which would gradually grow fainter until they would occasionally almost disappear from view. Repeated trials showed that the time of true internal contact was marked by the moment at which light entirely ceased to glimmer across the dark space

formed by the approach of the limb of the planet to that of the Sun.

(6) Every attempt to estimate an apparent contact, or moment at which the limbs of *Venus* and the Sun were tangent to each other, without reference to the appearance of the thread of light, was a total failure. It was, in fact, impossible to make any such estimate without an uncertainty of half a minute or more. This will not appear surprising if we reflect that the outlines of *Venus* and the Sun cannot present themselves to the vision as geometric lines, but only as more or less indefinite edges of a visible surface of sunlight; which visible surface disappears most gradually near the region of contact, and, in fact, at the moment of ideal "apparent contact" cannot be seen at all at the point of contact. Anyone who wishes to satisfy himself on this point has only to examine a series of figures in which the black drop is represented, and try to decide which of them represents apparent contact. If he wishes to come as near nature as possible, he must shade off the outlines both of *Venus* and the Sun, so that they shall terminate in a soft border, and view the picture through a rising current of hot air.

(7) Any artificial representation of these phenomena, in which the bright surface of the Sun is surrounded by a dark background, must fail to be correct in a very important particular. As a matter of fact, we know that the atmosphere immediately around the Sun's limb is of dazzling brilliancy. In meridian observations of the Sun, when the light is so cut down by a dark glass as no longer to dazzle the eye, the five spider-lines are visible on the background of the atmosphere; else it would be impossible to observe the transit of the Sun's first limb. This brilliancy of the atmosphere must greatly diminish irradiation; and if the Sun is observed through haze (as must often be the case in observations of contact when the Sun is near the horizon), irradiation may be entirely destroyed. It will therefore be impossible to observe an actual internal contact of *Venus* or *Mercury* with a precision corresponding to that of an artificial contact on a black background.

(8) The atmosphere affects the phenomena of contact in three ways:—

α. By illuminating the background as just described.

β. By producing undulations in the outlines of the images, thereby preventing the phenomena from being invariable.

γ. By softening the outlines of the Sun's limb, and thus rendering it more or less indefinite.

The artificial transit to which I have alluded was placed at a distance, in order that all these effects might be produced and studied; otherwise, the optic phenomena of contact may be entirely different. For instance, because the black drop is sharply seen in the artificial transit when the background is quite black, it does not follow that it will be noticed in the actual transit.

(9) A good idea of many of the causes of uncertainty to

which I have alluded may be formed by examining a series of photographs of internal contact taken by the Janssen process. One will immediately appreciate the distinction on which I have insisted, between geometric lines on the one hand and the outlines of *Venus* and the Sun on the other.

(10) I have said little of the black drop; partly because I do not think there can be much room for a real difference of opinion respecting its nature and causes, and partly because the question whether it is seen is of entirely secondary importance, except as affording some indication of the sharpness of definition. In looking at the artificial transit, it was very easy, about the moment of internal contact, by taking a general mean outline of the undulating image of the planet, and imagining that outline continued across the undulating line of light and darkness mixed, into which the ideal thread was reduced by the imperfections of vision, to see something like a black drop. On the other hand, another observer, with his attention fixed solely on the thread of light, would see nothing of the sort. The final disappearance of the thread of sunlight being the only phase which can be actually observed, an observer fixing his attention exclusively on this would not see any black drop at all, unless the amount of irradiation was exceptionally great.

(11) I see little or nothing in Mr. Stone's views radically inconsistent with those which I have here set forth. His remark on his observation of the egress of *Venus* in 1874, "the apparent contact was rendered more difficult than would otherwise have been the case by the appearance of this ligament, or, in other words, by the disappearance of a sensible portion of the Sun's limb near the point of contact," is in entire accord with the views I have expressed in paragraph 6.

(12) The general conclusion to which I am led is that there is but one phase of each contact which can be observed with any approach to accuracy, namely:—

α. The time when the notch made by *Venus* advancing on the Sun becomes visible.

β. The time at which true sunlight is first seen all the way around the following limb of the planet.

γ. The planet approaching egress, the time when it first completely cuts off the true limb of the Sun, and the space connecting the limb of the planet with the sky becomes as dark as the planet itself.

δ. The time when the last limb of the planet, leaving the limb of the Sun, disappears from view.

If an observer, at the time of internal contact, does not note, or try to note, the phases β and γ, there is no definite phase to which his observation can be referred. The old notion that at second internal contact there is a sudden formation of the black drop, which marks the moment of true contact, has been so completely exploded that it needs no further refutation. The more clear and dark the atmosphere around the Sun, the more rapidly

will contact appear to form, whether a black drop is seen or not; but under no circumstances under which an actual transit is likely to be observed for parallax will it be really sudden. When it appears so it is only because the observer failed to notice the gradual darkening and breaking up of the thread of light. From the commencement of this darkening and diffusion, until the "apparent contact," which comes last of all, there are a series of progressive changes, which may extend over a period ranging anywhere from twenty or thirty to ninety seconds, at any point of which a random observation of internal contact may fall. The worse the definition, and the lower the planet, the greater the range; but the time of true contact is always near the mean of the period.

Washington,
1877, *February* 22.

Ephemeris for Physical Observations of Jupiter 1877.

By Mr. A. Marth.

Greenwich Noon. 1877.	Angle of position of ♃'s Axis.	Longitude of ♃'s Meridian directed to the Earth.	diff.	Latitude of Earth above ♃'s Equator.	Latitude of Sun above ♃'s Equator.	Annual Parallax.	diff.	Equatoreal Diameter.
	°	°	°	°	°	°	°	″
Mar. 31	357·72	104·8		−2·31	−2·45	−10·81		38·71
			4353·1				+ ·14	
Apr. 5	357·59	137·9		2·31	2·43	10·67		39·33
			3·2				·21	
10	357·51	171·1		2·30	2·42	10·46		39·96
			3·3				·29	
15	357·46	204·4		2·30	2·41	10·17		40·59
			3·3				·37	
20	357·44	237·7		2·29	2·39	9·80		41·22
			3·4				·45	
25	357·46	271·1		2·29	2·38	9·35		41·85
			3·5				·53	
30	357·52	304·6		2·29	2·37	8·82		42·46
			3·5				·61	
May 5	357·61	338·1		−2·28	−2·35	−8·21		43·04
			3·6				·67	
10	357·74	11·7		2·28	2·34	7·54		43·60
			3·6				·75	
15	357·90	45·3		2·28	2·32	6·79		44·13
			3·6				·82	
20	358·09	78·9		2·28	2·31	5·97		44·60
			3·7				·87	
25	358·31	112·6		2·28	2·30	5·10		45·03
			3·7				·93	
30	358·55	146·3		2·28	2·28	4·17		45·40
			3·7				·97	
June 4	358·82	180·0		−2·28	−2·27	−3·20		45·69
			3·7				1·01	
9	359·10	213·7		2·28	2·25	2·19		45·92
			3·7				1·03	